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Original Research Article

Comparison of Recovery Characteristics of Isoflurane, Sevoflurane, and Propofol in Patients Undergoing Laparoscopic Surgeries for Early Extubation

Kotagiri Raghavendra[1], Kiran Kumar Suggala[2], T. Anusha[3], Ganapaneni Sarasangi[4], Abbu Kanishka Reddy[5], C. Sai Prathima[6]

[1]Junior Resident, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

[2]Professor & Head of Department, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

[3]Associate Professor, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

[4]Junior Resident, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

[5]Junior Resident, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

[6]Junior Resident, Department of Anaesthesiology, Mamata Medical College, Khammam, Telangana, India.

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Corresponding author: Dr. Kiran Kumar Suggala

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Abstract

Introduction: General anaesthesia is an integral part of modern surgical practice, and the choice of maintenance agent can significantly influence intraoperative hemodynamics and postoperative recovery. Isoflurane, Sevoflurane, and Propofol are among the most widely used anaesthetic agents, each with unique pharmacodynamic profiles that may impact clinical outcomes. The study aimed to compare Isoflurane, Sevoflurane, and Propofol with respect to intraoperative haemodynamic stability and postoperative recovery profile in adult patients undergoing elective surgeries under general anaesthesia.

Materials and Methods: This prospective, randomized, comparative study was conducted at Mamata Medical College, Khammam, from January 2024 to June 2025, including 150 ASA I–II patients aged 18–60 years. Participants were randomly allocated into three groups (n=50 each): Isoflurane, Sevoflurane, and Propofol. Standard induction was followed by maintenance with the assigned anaesthetic technique. Haemodynamic parameters (heart rate, SBP, DBP, SpO_2, $EtCO_2$) were recorded at baseline and at 15, 30, 45, and 60 minutes intraoperatively. Recovery profile was assessed by time to eye opening and ambulation. Data were analyzed using ANOVA and Chi-square tests, with $p<0.05$ considered significant.

Results: Isoflurane and Sevoflurane maintained hemodynamics within ±15% of baseline, whereas Propofol showed a greater fall in SBP/DBP ($p<0.001$ at 15 min). Time to eye opening and ambulation were significantly faster with Sevoflurane, followed by Isoflurane and Propofol ($p<0.001$). SpO_2 and $EtCO_2$ remained stable across all groups.

Conclusion: Sevoflurane provides superior haemodynamic stability and fastest recovery, making it the preferred agent for short-duration procedures requiring early mobilization.

Keywords: Isoflurane, Sevoflurane, Propofol.

Introduction

General anaesthesia is a cornerstone of modern surgical practice, providing unconsciousness, analgesia, and muscle relaxation to facilitate surgery safely and comfortably [1]. The choice of anaesthetic agent plays a vital role in determining intraoperative haemodynamic stability, postoperative recovery profile, and overall patient outcomes [2,3]. Inhalational agents such as Isoflurane and Sevoflurane, and intravenous agents such as Propofol, are among the most commonly used drugs for maintenance of anaesthesia [4,5]. Each agent has distinct pharmacodynamic and

pharmacokinetic properties that influence cardiovascular function and recovery time [6]. Volatile anaesthetic agents like Isoflurane and Sevoflurane are known for their ease of administration, titratability, and predictable depth of anaesthesia [7]. Isoflurane has been widely used for several decades and is associated with relative haemodynamic stability [8]. Sevoflurane, a newer agent, is preferred for its low blood-gas solubility, allowing rapid induction and emergence from anaesthesia, making it particularly useful in short procedures and ambulatory surgeries [9].

Propofol, on the other hand, is an intravenous agent valued for its smooth induction, rapid clearance, and antiemetic properties [10]. However, its use as a sole agent for maintenance can be associated with significant hypotension and delayed emergence, especially in prolonged procedures [10,11]. The differential effects of these agents on heart rate, blood pressure, oxygenation, ventilation, and recovery characteristics warrant a systematic comparison to guide optimal drug selection in clinical practice [12,13].

The present study was undertaken to compare Isoflurane, Sevoflurane, and Propofol with respect to intraoperative haemodynamic stability (heart rate, systolic and diastolic blood pressure, SpO_2, $EtCO_2$) and recovery profile (time to eye opening and ambulation) in adult patients undergoing elective surgeries under general anaesthesia.

Materials and Methods

This prospective, randomized, comparative study was conducted at Mamata Medical College, Khammam, after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. The study was carried out over an 18-month period from January 2024 to June 2025. A total of 150 adult patients scheduled for elective surgical procedures under general anaesthesia were included. Participants were aged between 18 and 60 years and belonged to American Society of Anaesthesiologists (ASA) physical status I or II. Patients with significant cardiovascular, respiratory, hepatic, or renal disorders, those with a history of difficult airway or allergy to study drugs, and pregnant or lactating women were excluded. Eligible patients were randomly allocated into three groups of 50 each: Group I (Isoflurane), Group S (Sevoflurane), and Group P (Propofol), using a computer-generated randomization table.

All patients underwent a standardized pre-anaesthetic assessment, including history, physical examination, and baseline investigations. In the operating room, standard monitors were applied, and baseline parameters including heart rate, systolic and diastolic blood pressure, oxygen saturation (SpO_2), and end-tidal carbon dioxide ($EtCO_2$) were recorded. Anaesthesia was induced with standard intravenous agents, followed by the assigned maintenance technique as per group allocation. Hemodynamic parameters were measured at baseline (0 min) and at 15, 30, 45, and 60 minutes intraoperatively. Recovery profile was assessed by recording time to eye opening and time to ambulation.

Data were entered in Microsoft Excel and analyzed using SPSS version 27. Continuous variables were expressed as mean ± standard deviation (SD) and compared using one-way ANOVA followed by post hoc Tukey test where applicable. Categorical variables were presented as frequencies and percentages and compared using Chi-square test or Fisher's exact test. A p-value of < 0.05 was considered statistically significant.

Results

The three groups were comparable with respect to age, gender distribution, body weight, ASA physical status, and duration of surgery, with no statistically significant differences observed among them ($p > 0.05$). This ensured adequate baseline comparability between the Isoflurane, Sevoflurane, and Propofol groups (Table 1).

Table 1: Demographic Characteristics

Variable	Group I (Isoflurane) (n=50)	Group S (Sevoflurane) (n=50)	Group P (Propofol) (n=50)	p-value
Age (years)	38.6 ± 10.4	37.9 ± 11.2	39.1 ± 9.8	0.81
Gender (M/F)	26 / 24	24 / 26	25 / 25	0.92
Weight (kg)	62.8 ± 7.6	63.1 ± 8.0	62.2 ± 7.2	0.87
ASA I / II	32 / 18	33 / 17	31 / 19	0.93
Duration of Surgery (min)	68.4 ± 15.3	69.1 ± 14.9	67.8 ± 15.7	0.89

Heart rate showed an initial increase at 15 minutes in all three groups, followed by a progressive decline toward baseline and below, with the lowest values recorded at 45 and 60 minutes. The difference between groups reached statistical significance only at 60 minutes, where Isoflurane maintained a slightly higher mean heart rate compared to the other two agents ($p = 0.03$) (Table 2).

Table 2: Heart Rate Trends (bpm)

Time	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)	p-value
0 min	74.9 ± 3.5	75.6 ± 3.8	75.2 ± 3.6	0.72
15 min	83.8 ± 6.2	82.5 ± 6.5	81.3 ± 6.8	0.41
30 min	77.2 ± 4.6	76.4 ± 4.8	75.1 ± 4.7	0.38
45 min	69.1 ± 5.0	67.5 ± 4.9	66.2 ± 4.8	0.09
60 min	69.0 ± 4.3	66.8 ± 4.7	65.8 ± 4.5	**0.03**

Systolic blood pressure demonstrated an initial fall at 15 minutes in all groups, which was most pronounced in the Propofol group, showing a statistically significant difference ($p < 0.001$). Subsequent measurements at 30, 45, and 60 minutes showed a gradual rise toward baseline in all groups, with no significant intergroup variation beyond the first 15 minutes (Table 3).

Table 3: Systolic Blood Pressure (mmHg)

Time	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)	p-value
0 min	137 ± 12	138 ± 12	141 ± 15	0.49
15 min	119 ± 7	118 ± 7	107 ± 8	**<0.001**
30 min	120 ± 9	122 ± 9	117 ± 9	0.06
45 min	125 ± 9	127 ± 9	124 ± 9	0.18
60 min	130 ± 9	131 ± 8	132 ± 9	0.51

Diastolic blood pressure followed a similar pattern, with a marked fall at 15 minutes in the Propofol group compared to Isoflurane and Sevoflurane ($p < 0.001$). Beyond this point, values gradually returned toward baseline and the intergroup differences lost statistical significance (Table 4).

Table 4: Diastolic Blood Pressure (mmHg)

Time	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)	p-value
0 min	76 ± 8	76 ± 8	77 ± 9	0.84
15 min	68 ± 6	67 ± 6	60 ± 5	**<0.001**
30 min	69 ± 7	71 ± 7	67 ± 7	0.08
45 min	72 ± 7	73 ± 6	71 ± 6	0.23
60 min	73 ± 7	74 ± 6	74 ± 6	0.74

Oxygen saturation (SpO_2) remained stable and comparable across all three groups throughout the perioperative period, with no clinically relevant desaturation events or significant differences ($p > 0.05$) (Table 5).

Table 5: Oxygen Saturation (SpO_2 %)

Time	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)	p-value
0 min	98.0 ± 0.8	97.9 ± 0.8	98.2 ± 0.7	0.67
15 min	97.9 ± 1.1	97.8 ± 1.0	98.1 ± 1.0	0.64
30 min	97.8 ± 1.0	97.9 ± 0.9	98.0 ± 0.9	0.72
45 min	98.0 ± 0.9	98.0 ± 1.1	98.1 ± 1.1	0.80
60 min	98.1 ± 1.1	97.9 ± 1.0	98.2 ± 1.1	0.76

End-tidal CO_2 ($EtCO_2$) showed a mild decline from baseline in all groups after induction but remained within normal physiological limits throughout the surgery. No statistically significant differences were noted at any time interval (Table 6).

Table 6: End-Tidal CO_2 ($EtCO_2$ mmHg)

Time	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)	p-value
0 min	32.8 ± 1.9	32.9 ± 2.0	33.4 ± 1.8	0.58
15 min	29.0 ± 2.0	28.9 ± 2.7	28.2 ± 2.2	0.42
30 min	26.9 ± 1.9	27.1 ± 2.6	26.9 ± 2.5	0.93
45 min	27.5 ± 2.3	27.0 ± 2.8	27.2 ± 2.7	0.71
60 min	27.0 ± 2.2	27.3 ± 2.7	27.0 ± 2.3	0.82

Time to eye opening was significantly faster with Sevoflurane (mean 2.3 ± 0.8 min) compared to Isoflurane (3.0 ± 1.0 min) and Propofol (7.8 ± 1.5 min), with the majority of Propofol patients requiring ≥ 5 minutes for recovery of consciousness ($p < 0.001$) (Table 7).

Table 7: Comparison of Early Recovery – Time to Eye Opening

Eye Opening (min)	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)
≤ 2 min	24 (48%)	32 (64%)	0 (0%)
3–4 min	18 (36%)	14 (28%)	5 (10%)
≥ 5 min	8 (16%)	4 (8%)	45 (90%)
Mean ± SD	3.0 ± 1.0	2.3 ± 0.8	7.8 ± 1.5
p-value	**<0.001**		

Time to ambulation followed a similar trend, with Sevoflurane demonstrating the earliest mobilization (mean 5.3 ± 0.7 hrs) followed by Isoflurane (6.2 ± 1.1 hrs) and Propofol (9.1 ± 1.8 hrs), a difference that was highly significant ($p < 0.001$) (Table 8).

Table 8: Comparison of Late Recovery – Time to Ambulation

Time to Walk (hrs)	Group I (Isoflurane)	Group S (Sevoflurane)	Group P (Propofol)
≤ 5 hrs	28 (56%)	38 (76%)	0 (0%)
6–8 hrs	18 (36%)	12 (24%)	6 (12%)
≥ 9 hrs	4 (8%)	0 (0%)	44 (88%)
Mean ± SD	6.2 ± 1.1	5.3 ± 0.7	9.1 ± 1.8
p-value	**<0.001**		

Discussion

In the present study, haemodynamic parameters including heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were maintained within ±15% of baseline values in the Isoflurane and Sevoflurane groups, whereas Propofol showed a slightly greater fall (within ±30%), though all remained clinically acceptable. The concentrations of Isoflurane (0.8–1.5%), Sevoflurane (1–3.5%), and Propofol (60–150 µg/kg/min) were titrated to maintain adequate anaesthetic depth, and intraoperative analgesia was supplemented with fentanyl infusion across all groups. These findings are consistent with those of Khare et al., who observed stable heart rate and blood pressure across propofol and sevoflurane groups, though propofol was associated with somewhat lower blood pressures at various time points ($p < 0.05$) in laparoscopic cholecystectomy patients, but still within safe limits [14].

Early recovery, measured as time to eye opening, was significantly shorter in the Sevoflurane group compared to Isoflurane and Propofol groups ($p < 0.001$). These findings are consistent with the results of Erk G et al., who demonstrated shorter eye opening and extubation times with Sevoflurane compared to Isoflurane and Propofol [15]. Although Isoflurane was associated with slightly longer early recovery times than Sevoflurane, its performance was still superior to Propofol, making inhalational agents favourable for rapid emergence in short-duration procedures. Late recovery characteristics in our study, assessed by time to ambulation, also demonstrated a clear advantage with Sevoflurane, followed by Isoflurane, whereas Propofol showed delayed ambulation. These results align with those of Elbakry AE et al., who reported that Sevoflurane facilitated faster immediate and intermediate recovery compared to Propofol [16]. Early mobilization after surgery is clinically relevant, particularly in day care laparoscopic surgeries, where rapid turnover and reduced hospital stay are desired outcomes.

Our findings further corroborate the observations of Korat RR et al. and Singh SK et al., who highlighted that inhalational agents like Isoflurane and Sevoflurane provide faster elimination and earlier recovery compared to Propofol, a difference attributed to their lower blood-gas solubility and favourable pharmacokinetics [17,18]. This reinforces the recommendation that inhalational agents, particularly Isoflurane, may be preferred for procedures requiring early extubation and rapid recovery.

Limitations of the study include its single-center design, which may limit generalizability of the findings, and the lack of assessment of postoperative nausea and vomiting (PONV) or other adverse effects, which could provide a more comprehensive comparison of recovery quality. Furthermore, long-term outcomes such as time to discharge readiness and patient satisfaction were not evaluated. Future multicentric studies with larger sample sizes and inclusion of additional recovery parameters are recommended for stronger external validation.

Conclusion

The present study demonstrates that Isoflurane and Sevoflurane provide superior haemodynamic stability and significantly faster recovery profiles compared to Propofol in adult patients undergoing elective surgeries under general anaesthesia. Sevoflurane was associated with the shortest time to eye opening and ambulation, making it particularly advantageous for procedures where

early emergence and mobilization are desired. Isoflurane, while slightly slower than Sevoflurane, still outperformed Propofol, supporting its use in cases requiring smooth and predictable recovery. Although Propofol produced a greater early fall in blood pressure, all agents maintained clinically acceptable haemodynamic parameters. Considering the faster recovery and comparable intraoperative stability, inhalational agents, especially Sevoflurane may be preferred for short-duration surgeries and settings where rapid turnover is essential. Future multicentric trials incorporating assessment of postoperative adverse effects, discharge readiness, and patient satisfaction would help in refining anaesthetic drug selection for optimal perioperative outcomes.

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